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Final Technical Report
For Grant No. F49620-96-1-0175

The research supported by AFOSR Grant Number: F49620-96-1-0175 had three primary scientific objectives. First, we sought to develop more fully the connection between atomic collisions and the interaction of atoms with strong, brief pulses of electromagnetic radiation. Second, we investigated new techniques for viewing the dynamic evolution of electrons within atoms and utilized these approaches to observe electronic motion during and subsequent to well controlled "mock" charged particle collisions. Third we explored new methods for generating and detecting short pulses of higher power THz radiation. This work benefits the Air Force in that it provides a deeper understanding of fundamental atomic collision processes and may aid in the development of high power sources and detectors for short pulses of THz radiation for communication and identification.

Important results during the funding period from June 1, 1996 through November 30, 1998 include:

1. The development and demonstration of the Impulsive Momentum Retrieval (IMR) method for directly viewing the momentum distribution of electrons within atoms.
2. The development and demonstration of a "single-shot" delay imaging detector that allows us to view electron dynamics in quasi-real time.
3. Measurement of atomic ionization probability in a full mock-collision field, including both longitudinal and transverse field components.
4. Demonstration and preliminary studies of free electron-ion recombination in mock collisions.
5. Identified Stark wavepackets, coherent superpositions of "stretched" atomic states as potentially useful sources of short-pulses (only a few optical cycles) of tunable THz radiation.

Full details of these and other results are included in the three annual progress reports submitted previously, in the renewal proposal submitted in August 1998, and in the publications listed below.

Publications Acknowledging AFOSR Support During the Grant Period:

1. R.R. Jones, "Creating and Probing Electronic Wavepackets Using Half-Cycle Pulses," Phys. Rev. Lett. **76**, 3927 (1996).
2. T.J. Bensity, G. Haefliger, and R.R. Jones, "Ionization of Na Rydberg Atoms by Subpicosecond Quarter-Cycle Circularly Polarized Pulses," Phys. Rev. Lett. **79**, 2018 (1997).
3. M.B. Campbell, T.J. Bensity, and R.R. Jones, "Single-shot Detection of Wavepacket Evolution," Opt. Express **1**, 197 (1997).

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Contributed Presentations Acknowledging AFOSR Support During the Grant Period:

1. T.J. Bensky, M.B. Campbell, and R.R. Jones, "Ion-Electron Recombination Using Subpicosecond Half-Cycle Pulses," Annual Meeting of the APS Division of Atomic, Molecular, and Optical Physics, Santa Fe, NM, May 1998.
2. M.B. Campbell, T.J. Bensky, and R.R. Jones, "Measurement of the Probability Distribution of Stark Wavepackets," Annual Meeting of the APS Division of Atomic, Molecular, and Optical Physics, Santa Fe, NM, May 1998.
3. M.B. Campbell, B.L. Wood, T.J. Bensky, and R.R. Jones, "Single-Shot Detection of Wavepacket Evolution," Annual Meeting of the APS Division of Atomic Molecular and Optical Physics, Washington, DC, April 18, 1997.
4. T.J. Bensky, G. Haeffler, and R.R. Jones, "Ionization of Sodium Rydberg Atoms by Subpicosecond Quarter-Cycle Circularly Polarized Pulses," Annual Meeting of the APS Division of Atomic Molecular and Optical Physics, Washington, DC, April 18, 1997.

Principal Investigator Awards During the AFOSR Grant Period:

1. Tenured Promotion to Associate Professor – June 1998
2. David and Lucile Packard Fellowship - October 1996
3. Oak Ridge Associated Universities Physical Science Award - June 1996

Dissertations Produced During the AFOSR Grant Period:

T.J. Bensky, "Rydberg Atoms & Half-Cycle Pulses," University of Virginia, August 1998.

4. R.R. Jones and L.D. Noordam, "Electronic Wavepackets," *Adv. in At., Mol., and Opt. Phys.* **38**, 1 (1997).
5. L.D. Noordam and R.R. Jones, "Probing Rydberg Electron Dynamics," *J. of Mod. Optics* **44**, 2515 (1997).
6. M.B. Campbell, T.J. Bensky, and R.R. Jones, "Probing Electronic Radial Wavepackets Using Impulsive Momentum Retrieval," *Phys. Rev. A* **58**, 514 (1998).
7. T.J. Bensky, M.B. Campbell, and R.R. Jones, "Half-Cycle Pulse Assisted Electron-Ion Recombination," *Phys. Rev. Lett.* **81**, 3112 (1998).
8. R.R. Jones, "Isolated-Core Excitation Spectroscopy of the $4p_{1/2,3/2}$ nd $J = 1,3$ Series in Calcium," *Phys. Rev. A* **58**, 2608 (1998).

Invited Talks Acknowledging AFOSR Support During the Grand Period:

1. R.R. Jones, "Manipulating Electronic Wavefunctions," Department of Energy Atomic, Molecular, and Optical Physics Research Meeting, Ellicott City, MD, October 1998.
2. R.R. Jones, "Manipulating Electronic Wavefunctions," Laser Physics '98, Berlin, Germany July 6-10, 1998.
3. R.R. Jones, "Rydberg Wavepacket Dynamics," Multiphoton Gordon Conference, Tilton, NH, June 14-19, 1998.
4. R.R. Jones, "Building Electronic Wavepackets from Scratch," International Quantum Electronics Conference 1998, San Francisco, CA, May 3-8, 1998.
5. R.R. Jones, "Kicking Big Atoms with Short Light Pulses," Physics Department Colloquium, Ohio State University, Columbus OH, November 18, 1997.
6. R.R. Jones, "Kicking Big Atoms with Short Light Pulses," Physics Department Colloquium, University of Virginia, Charlottesville, VA, October 31, 1997.
7. R.R. Jones, "Electron Dynamics in Rydberg Atoms Exposed to Intense THz Radiation," Atomic Physics Gordon Conference, Henniker, NH, July 2, 1997.
8. R.R. Jones, "Half-cycle, Terahertz Manipulation of Wavepackets," 12th Interdisciplinary Laser Science Conference, Rochester, NY, October 22, 1996.
9. R.R. Jones, "Kicking Big Atoms Using Short Light Pulses," Physics Colloquium, Auburn University, Auburn, AL, October 4, 1996.
10. R.R. Jones, "Creating and Probing Electronic Wavepackets Using Half-Cycle Pulses," APS Division of Atomic, Molecular, and Optical Physics, Ann Arbor, MI, May 1996.